1. Which of the following abbreviated structural formulas is NOT an isomer of the others?
   A)  
   B)  
   C)  
   D)  
   E)  

2. The structural formula \[
\begin{array}{c}
\text{cycle} \\
\end{array}
\] has the molecular formula:
   A) \(C_7H_{16}\)  
   B) \(C_6H_{14}\)  
   C) \(C_7H_{14}\)  
   D) \(C_6H_{12}\)  
   E) \(C_7H_{10}\)  

3. Which of the following structural formulas has the molecular formula \(C_6H_{12}\)?
   A) 2 and 3  
   B) 1 and 4  
   C) 1, 4, and 5  
   D) 1 and 2  
   E) 4 and 5
4. What is the formal charge of N in HNO₃, as seen below?

A) +1
B) +2
C) 0
D) −1
E) −2

5. The approximate H–C–H bond angle in methane is:
A) 60°
B) 90°
C) 109.5°
D) 120°
E) 180°

6. Which of the following molecules is acyclic?
A) [Image of cyclohexane]
B) [Image of alkene]
C) [Image of cycloalkane with OH group]
D) [Image of benzene]
E) [Image of branched alkane]

7. Which of the following molecules contain the same functional group?
A) 2 and 3
B) 1, 2 and 4
C) 2 and 4
D) 1 and 2
E) 1 and 4

8. What is the common name for the following molecule?

CH₃CHCH₂Br

A) isobutyl bromide
B) tert-butyl bromide
C) butyl bromide
D) sec-butyl bromide
E) bromo-sec-butane
9. The name of the alkyl group below is:

\[
\begin{array}{c}
\text{CH}_3 \\
\text{CH} \\
\text{CH}_3
\end{array}
\]

A) Ethyl
B) Propyl
C) Isopropyl
D) Butyl
E) Isobutyl

10. The IUPAC name for the following molecule is:

\[\text{\includegraphics[width=1in]{molecule.png}}\]

A) 2-ethyl-4-methylpentane
B) 4-methyl-2-methylpentane
C) 2,4-dimethylhexane
D) 1-isopropyl-2-methylbutane
E) 2,4-methylhexane

11. What is the correct name for the following cycloalkane?

\[\text{\includegraphics[width=1in]{cycloalkane.png}}\]

A) bromoethylcyclohexane
B) trans-1-ethyl-3-bromocyclohexane
C) cis-3-bromo-1-ethylhexane
D) 1-bromo-3-ethylcyclohexane
E) cis-1-bromo-3-ethylcyclohexane

12. The preferred conformation of cis-3-tert-butyl-1-methylcyclohexane is the one in which:
A) the tert-butyl group is axial and the methyl group is equatorial
B) both groups are axial
C) both groups are equatorial
D) the methyl group is axial and the tert-butyl group is equatorial
E) molecule exists in a boat conformation

13. How many monobromo products can be obtained from the bromination of cyclopentane?
A) 1
B) 2
C) 3
D) 4
E) 5

all identical H's
14. Which of the following dienes can be classified as conjugated?
   A) CH₃CH=C=CH₂
   B) CH₂=CHCH=CH₂
   C) CH₂=CHCH₂CH=CH₂
   D) CH₃CH=CHCH₂CH₂CH=CH₂
   E) CH₂=C=CH₂

15. What is the correct name for the following molecule?

   A) 1-ethylcyclohexene
   B) 2-ethylcyclohexene
   C) 3-ethylcyclohexene
   D) cyclohexylethane
   E) 1-ethyl-3-cyclohexene

16. The correct IUPAC name for the following molecule is:

   A) trans-2,3-dichloro-5-methyl-2-hexene
   B) trans-2,3-dichloro-5-methyl-3-hexene
   C) cis-2,3-dichloro-5-methyl-3-hexene
   D) trans-4,5-dichloro-2-methyl-4-hexene
   E) cis-4,5-dichloro-2-methyl-4-hexene

17. The first step in the free radical mechanism for the preparation of polyethylene is:
   A) formation of a stable carbocation
   B) formation of a stable carbanion
   C) heating an organic peroxide to break the O–O bond
   D) decoupling of the free radicals
   E) propagation of the free radicals
18. The multiple bonds in the following compounds are conjugated:

1. \( \text{CH}_2=\text{C}=\text{CH}_2 \)
2. \( \text{CH}_2=\text{C}=-\text{C}=\text{CH}_2 \)  
3. \( \text{CH}_2=\text{CH}-\text{CH}=\text{O} \) 
4. 
5. \( \text{CH}_3-\text{C}=\text{C}-\text{CH}=\text{CH}_2 \)

A) 2, 3, and 5
B) 4 and 6
C) only 1

D) 2 and 3
E) 2 and 5

19. What would be the major product of the following reaction?

\[ \text{CH}_3 \]
\[ \text{Cyclohexene} \] + \( \text{HBr} \) → ?

Markovnikov's Addition

A) I
B) II
C) III

D) IV
E) V
20. Upon ozonolysis and treatment with Zn in water, compound A yielded two moles of formaldehyde, HCHO, and 1 mole of the following molecule:

\[
\begin{align*}
\text{CH}_3\text{CCH}_2\text{CCH}_3
\end{align*}
\]

What is the structure of A?

A) I  B) II  C) III  D) IV  E) V

21. The product of the reaction sequence

\[
\begin{align*}
\text{Is} & \xrightarrow{\text{BH}_3} \xrightarrow{\text{H}_2\text{O}_2} \text{anti-Markovnikov's product}
\end{align*}
\]

A)  
B)  
C)  
D)  
E) none of the above
22. Examine the following reaction energy diagram for the reaction

\[ \text{A} + \text{B} \rightarrow \text{C} + \text{D} \]

Energy

Reaction Coordinate

Which of the following statements are true?
1. The reaction is exothermic.
2. The reaction occurs in one step.
3. The first step is the rate-determining step.
4. The reaction is endothermic.
5. If the reaction is heated, the reaction rate will increase.

A) 1, 2, and 5  
B) 1, 3, and 5  
C) 2 and 4  
D) 3, 4, and 5  
E) 3 and 4

23. Select the necessary reagent(s) to convert cycloheptene to cycloheptane.

A) H₂ and Ni  
B) H₂O  
C) H₂SO₄ and heat  
D) Zn and H⁺  
E) KOH in alcohol and heat

24. Select the necessary reagents to convert 1-methylcyclopentene to 1-methylcyclopentanol.

A) H₂O and H₂SO₄  
B) Zn, H₂O  
C) BH₃, then H₂O₂ and -OH  
D) O₃, then Zn, H⁺  
E) KOH in alcohol and heat
25. Upon ozonolysis which alkene will give only acetone, \((\text{CH}_3)_2\text{C}=\text{O}\)?

A) 2,3-dimethyl-2-butene  
B) 2,2-dimethyl-2-butene  
C) 3-hexene

D) 2-methyl-2-pentene  
E) 2-methyl-3-hexene

**Extra credit question**

26. The Diels-Alder reaction is very important in the synthesis of six-membered rings. What six-membered ring is produced with the following reaction?

\[
\text{CH}_3\text{CH}==\text{CHCH}==\text{CHCH}_3 \quad + \quad \text{H}_2\text{C}==\text{CHCCH}_3 \quad \rightarrow \quad ?
\]

A)  

B)  

C)  

D)  

E)  

\[
\text{CH}_3\text{CH}==\text{CHCH}==\text{CHCH}_3 \rightarrow \quad \text{C}_6\text{H}_5\text{CHO}
\]